(2003-062009)

[DOCUMENT NAME] Specification

[TITLE OF THE INVENTION]

FUEL CELL

[CLAIMS]

[Claim 1]

A fuel cell, comprising:

power generation units each including anode, cathode and an electrolyte interposed between said anode and said cathode, said cathode including a first electrically conductive gas diffusion layer and said anode including a second electrically conductive gas diffusion layer, said power generation units including a first power generation unit and a second power generation unit adjacent to said first power generation unit,

wherein said first electrically conductive gas diffusion layer of said cathode of said first power generation unit has a first end protruding toward said second power generation unit;

said second electrically conductive gas diffusion layer of said anode of said second power generation unit has a second end protruding toward said first power generation unit; and

said first end and said second end are electrically connected with each other by an electrically conductive member extending through at least said electrolyte.

[Claim 2]

A fuel cell according to claim 1, wherein said first and second ends have overlapping portions, and at least said electrolyte is interposed between said overlapping portions;

said overlapping portions are connected together by said electrically conductive member; and

said electrically conductive member is an electrically conductive rivet member.

[Claim 3]

A fuel cell according to claim 1 or 2,

wherein said electrolyte is an electrolyte membrane;

said power generation units are arranged in a same plane to form an MEA unit; and

said fuel cell further comprises first and second electrically insulating separators for sandwiching said MEA unit;

a fuel gas flow field facing said power generation units is provided on said first electrically insulating separator; and

an oxygen-containing gas flow field facing said power generation units is provided on said second electrically insulating separator.

[DETAILED EXPLANATION OF THE INVENTION]

[0001]

[TECHNICAL FIELD TO WHICH THE INVENTION PERTAINS]

The present invention relates to a fuel cell having a plurality of power generation units arranged in a same plane. Each of the power generation units includes an

anode, a cathode, and an electrolyte interposed between the anode and the cathode.

[0002]

[PRIOR ART]

Generally, a solid polymer electrolyte fuel cell employs a membrane electrode assembly (MEA) which includes two electrodes (anode and cathode), and an electrolyte membrane interposed between the electrodes. Each of the electrodes comprises an electrode catalyst layer of noble metal supported on a carbon base material. The electrolyte membrane is a polymer ion exchange membrane (cation exchange membrane). The membrane electrode assembly is a power generation unit interposed between separators (bipolar plates). The membrane electrode assembly and the separators make up a unit of a fuel cell (unit cell) for generating electricity. A predetermined number of the fuel cells are stacked together to form a fuel cell stack.

[0003]

In the fuel cell, a fuel gas (reactant gas) such as a gas chiefly containing hydrogen (hydrogen-containing gas) is supplied to the anode. The catalyst of the anode induces a chemical reaction of the fuel gas to split the hydrogen molecule into hydrogen ions (protons) and electrons. The hydrogen ions move toward the cathode through the electrolyte, and the electrons flow through an external circuit to the cathode, creating a DC electric current. A gas chiefly containing oxygen (oxygen-containing gas) or air

is supplied to the cathode. At the cathode, the hydrogen ions from the anode combine with the electrons and oxygen to produce water.

[0004]

For example, Patent Document 1 discloses another flat fuel cell in which a plurality of unit cells are arranged in the same plane in a single row, or a plurality of rows. The unit cells are electrically connected in series. FIG. 7 shows the flat fuel cell. The flat fuel cell includes unit cells 4a through 4d. Air electrodes (cathodes) 2a through 2d and fuel electrodes (anodes) 3a through 3d are provided on both sides of electrolyte layers 1a through 1d. The same electrodes are arranged on the same side of the electrolyte layers 1a through 1d, i.e., the cathodes 2a through 2d are arranged on one side of the electrolyte layers 1a through 1d, and the anodes 3a through 3d are arranged on the other side of the electrolyte layers 1a through 1d. Conductive Z-like connection plates 5a through 5d connect the unit cells 4a through 4d together in series.

[0005]

Specifically, the conductive Z-like connection plate 5a connects the cathode 2a of the unit cell 4a and the anode 3b of the unit cell 4b, the conductive Z-like connection plate 5b connects the cathode 2b of the unit cell 4b and the anode 3c of the unit cell 4c, and the conductive Z-like connection plate 5c connects the cathode 2c of the unit cell 4c and the anode 3d of the unit cell 4d. The anode 3a of the unit cell

4a is connected to a terminal 6a, and the cathode 2d of the unit cell 3d is connected to a terminal 6b.

[0006]

[Patent Document]

Japanese Laid-Open Patent Publication No. 2002-56855 (FIG. 1)

[0007]

[TASK TO BE SOLVED BY THE INVENTION]

According to the technique disclosed in Patent Document 1, the dedicated Z-like connection plates 5a through 5c are required for connecting the cathodes 2a through 2d and the anodes 3a through 3d of the unit cells 4a through 4d electrically in series. The Z-like connection plates 5a through 5c extend between the cathodes 2a through 2d and the anodes 3a through 3d, respectively. In this structure, the reliable sealing performance between the cathodes 2a through 2d and the anodes 3a through 3d may not be achieved.

[0008]

Moreover, the thickness of the fuel cell in the direction indicated by an arrow T is large. Thus, the overall size of the fuel cell is not small. Further, the unit cells 4a through 4d are separate components. Therefore, the unit cells 4a through 4d may not be positioned accurately in alignment with each other.

[0009]

In view of the above problems, a general object of the present invention is to provide a fuel cell having a simple

and compact structure in which a plurality of power generation units are electrically connected in series for achieving a desired level of voltage, and the power generation units are sealed desirably.

[0010]

[SOLUTION FOR THE TASK]

According to the fuel cell recited in claim 1 of present invention, a plurality of power generation units including a pair of adjacent power generation units are arranged in one plane. Each of the power generation units includes an electrolyte interposed between the anode and the cathode.

[0011]

In the adjacent first and second power generation units, the first electrically conductive gas diffusion layer of the first electrode of the first power generation unit has a first end protruding toward the second power generation unit, and the second electrically conductive gas diffusion layer of the second electrode of the second power generation unit has a second end protruding toward the first power generation unit. The first end and the second end are electrically connected with each other by an electrically conductive member extending through at least the electrolyte. When a reinforcing film is attached to the electrolyte, the electrically conductive member extends through the reinforcing film and the electrolyte for electrically connecting the first end and the second end.

[0012]

The cathode of the first power generation unit and the anode of the adjacent second power generation unit are electrically connected with each other through the first and second electrically conductive gas diffusion layers and the electrically conductive member. In this manner, the power generation units are connected in series.

[0013]

The first end of the first electrically conductive gas diffusion layer of the cathode of the second power generation unit is positioned close to the second end of the second electrically conductive gas diffusion layer of the anode of the adjacent third power generation unit. The first and second ends are positioned on both sides of the electrolyte, and the first and second ends are electrically connected with each other by the electrically conductive member extending through the electrolyte. Thus, the second power generation unit is electrically connected to the third power generation unit. In this manner, the first through third power generation units are electrically connected in series.

[0014]

Electrical connection between the power generation units is simply performed by the electrically conductive member which connects the first end of the first electrically conductive gas diffusion layer and the second end of the second electrically conductive gas diffusion

layer. Unlike the conventional structure, no dedicated Z-like connection plates are required for electrical connection. The fuel cell is produced at a low cost, and the reliable sealing performance can be achieved. The overall size of the fuel cell is small, and the overall structure of the fuel cell is simple.

[0015]

According to the fuel cell recited in claim 2, the first and second ends have overlapping portions, and at least the electrolyte is interposed between the overlapping portions. The overlapping portions are connected together by the electrically conductive member. Preferably, the electrically conductive member is an electrically conductive rivet member having a simple structure.

[0016]

According to the fuel cell recited in claim 3, the electrolyte is an electrolyte membrane, and the power generation units are arranged in a same plane to form an MEA unit. The fuel cell further comprises first and second electrically insulating separators for sandwiching the MEA unit. A fuel gas flow field facing the power generation units is provided on the first electrically insulating separator, and an oxygen-containing gas flow field facing the power generation units is provided on the second electrically insulating separator. With the structure, the overall size of the fuel cell is small, and the fuel cell is produced at a low cost.

[0017]

[MODE FOR CARRYING OUT THE INVENTION]

FIG. 1 is an exploded perspective view showing main components of a fuel cell 10 according to a first embodiment of the present invention. FIG. 2 is a cross sectional view showing main components of the fuel cell 10.

[0018]

The fuel cell 10 includes an MEA (membrane electrode assembly) unit 12, and first and second separators 14, 16 provided on both surfaces of the MEA unit 12.

[0019]

At a corner of the fuel cell 10 in directions indicated by arrows B and C, a fuel gas supply passage 18a for supplying a fuel gas such as a hydrogen-containing gas, and an oxygen-containing gas supply passage 20a for supplying an oxygen-containing gas are formed adjacent to each other. The fuel gas supply passage 18a and the oxygen-containing gas supply passage 20a extend through the fuel cell 10 in a direction indicated by an arrow A. Further, at another corner of the fuel cell 10 in the directions indicated by the arrows B and C, a fuel gas discharge passage 18b for discharging the fuel gas, and an oxygen-containing gas discharge passage 20b for discharging the oxygen-containing gas are formed adjacent to each other. The fuel gas discharge passage 18b and the oxygen-containing gas discharge passage 20b extend through the fuel cell 10 in the direction indicated by the arrow A.

[0020]

The MEA unit 12 includes a solid polymer electrolyte membrane 22 formed by impregnating a thin membrane of perfluorosulfonic acid with water, for example. The solid polymer electrolyte membrane 22 is a common electrolyte for making up a plurality of membrane electrode assemblies (power generation units) 24(1) through 24(n). As shown in FIG. 1, a predetermined number of the membrane electrode assemblies 24(1) through 24(n) are arranged in directions indicated by the arrows B and C in a plane of the solid polymer electrolyte membrane 22.

[0021]

As shown in FIG. 3, reinforcing films (e.g., silicon films) 26a, 26b are formed on both surfaces 22a, 22b of the solid polymer electrolyte membrane 22 around portions for providing the electrodes as described later. In the solid polymer electrolyte membrane 22, a plurality of holes 27 are formed at the predetermined positions.

[0022]

The membrane electrode assembly 24(1) includes a cathode 28 on one surface 22a of the solid polymer electrolyte membrane 22, and an anode 30 on the other surface 22b of the solid polymer electrolyte membrane 22. Each of the anode 30 and the cathode 28 is formed by coating the surface 22a, 22b with porous carbon particles which support platinum alloy. The cathode 28 includes a first electrically conductive diffusion layer 32, and the anode 30

includes a second electrically conductive diffusion layer 34.

[0023]

The membrane electrode assemblies 24(2) through 24 (n) have the same structure as the membrane electrode assembly 24(1). The constituent elements that are identical to those of the membrane electrode assembly 24(1) are labeled with the same reference numeral, and description thereof will be omitted.

[0024]

As shown in FIGS. 3 and 4, the first electrically conductive diffusion layer 32 of the membrane electrode assembly 24(1) has a first end 32a extending toward the adjacent membrane electrode assembly 24(2). The second electrically conductive diffusion layer 34 of the membrane electrode assembly 24(2) has a second 34a end extending toward the adjacent membrane electrode assembly 24(1).

[0025]

The first and second ends 32a, 34a partially overlap such that the solid polymer electrolyte membrane 22 and the silicon films 26a, 26b are interposed between overlapping portions of the first and second ends 32a, 34a. The overlapping portions are electrically connected with each other by an electrically conductive rivet member 36. A seal member 38 is formed around the outer surface of the rivet member 36 for sealing both surfaces of the solid polymer electrolyte membrane 22 hermetically. Flanges 36a, 36b

protruding toward the first end 32a and the second end 34a are formed by squeezing the rivet member 36.

[0026]

As shown in FIGS. 2 and 4, the first electrically conductive layer 32 of the membrane electrode assembly 24(2) has a first end 32a extending toward the adjacent membrane electrode assembly 24(3). The second electrically conductive diffusion layer 34 of the membrane electrode assembly 24(3) has a second end 34a extending toward the adjacent membrane electrode assembly 24(2). The overlapping portions of the first and second ends 32a, 34a are electrically connected by the rivet member 36. Likewise, the membrane electrode assemblies 24(3) through 24(n) are electrically connected in series.

[0027]

The first and second separators 14, 16 are made of insulating, and thermally conductive material such as reinforced plastic. As shown in FIGS. 1 and 5, the first separator 14 has a supply manifold 40 and a discharge manifold 42 on its surface 14a facing the MEA unit 12. The supply manifold 40 is formed on one side in the direction indicated by the arrow C, and the discharge manifold 42 is formed on the other side in the direction indicated by the arrow C. The supply manifold 40 and the discharge manifold 42 extend in the direction indicated by the arrow B. The supply manifold 40 includes a groove connected to the fuel gas supply passage 18a. The discharge manifold 42 includes

a groove connected to the fuel gas discharge passage 18b.

[0028]

A fuel gas flow field 44 is formed between the supply manifold 40 and the discharge manifold 42 for supplying the fuel gas to the anodes 30 of the MEA unit 12. The fuel gas flow field 44 includes a plurality of flow grooves extending in the direction indicated by the arrow C between the supply manifold 40 and the discharge manifold 42. Rectangular recesses 46 for providing the anodes 30 of the membrane electrode assemblies 24(1) through 24(n) are formed on the surface 14a. Further, a plurality of threaded holes 48 are formed at predetermined positions on the surface 14a.

[0029]

A seal 50 is formed around the fuel gas supply passage 18a, the fuel gas discharge passage 18b, the supply manifold 40, the discharge manifold 42, and the fuel gas flow field 44 by heat treatment, for example. The first separator 14 has a negative terminal 52 which is connectable to the anode 30 of the membrane electrode assembly 24(1).

[0030]

As shown in FIG. 6, the second separator 16 has a supply manifold 54 and a discharge manifold 56 on its surface 16a facing the MEA unit 12. The supply manifold 54 is connected to the oxygen-containing gas supply passage 20a, and extends in the direction indicated by the arrow B. The discharge manifold 56 is connected to the oxygen-containing gas discharge passage 20b, and extends in the

direction indicated by the arrow B. The supply manifold 54 and the discharge manifold 56 are connected by an oxygen-containing gas flow field 58. The oxygen-containing gas flow field 58 includes a plurality of flow grooves extending in the direction indicated by the arrow C.

[0031]

A seal 50 is formed around the oxygen-containing gas supply passage 20a, the oxygen-containing gas discharge passage 20b, the supply manifold 54, the discharge manifold 56, and the oxygen-containing gas flow field 58 by heat treatment, for example.

[0032]

Rectangular recesses 60 corresponding to the cathodes 28 of the membrane electrode assemblies 24(1) through 24 (n) are formed on the surface 16a. Seal-attached Holes 62 are formed at predetermined positions on the surface 16a. As shown in FIG. 1, tightening screws 64 are inserted through the seal-attached holes 62, and the holes 27 of the MEA unit 12, and screwed into the seal-attached threaded holes 48 of the first separator 14 for tightening the components of the fuel cell 10 together. The second separator 16 has a positive terminal 66 which is connectable to the cathode 28 of the membrane electrode assembly 24(n).

[0033]

As shown in FIG. 1, the second separator 16 has ribs 70 extending in the direction indicated by the arrow C on its surface 16b opposite to the surface 16a. A coolant flow

field is formed on the surface 16b by guide grooves 72 defined between the ribs 70.

[0034]

Next, operation of producing the fuel cell 10 will be described.

[0035]

Firstly, the silicon films 26a, 26b are attached to both surfaces 22a, 22b of the solid polymer electrolyte membrane 22. The silicon films 26a, 26b have cutouts corresponding to the shapes of the membrane electrode assemblies 24(1) through 24(n). Other films such as thin polyimide films may be used instead of the silicon films 26a, 26b.

[0036]

Next, a cathode electrolyte layer is formed on the surface 22a of the solid polymer electrolyte membrane 22 by coating, and an anode electrolyte layer is formed on the surface 22b of the solid polymer electrolyte membrane 22. Thus, the solid polymer electrolyte membrane 22 is interposed between the cathode 28, and the anode 30. A predetermined number of membrane electrode assemblies 24(1) through 24(n) are used for forming the MEA unit 12.

[0037]

The first electrically conductive diffusion layer 32 and the second electrically conductive diffusion layer 34 are provided on both surfaces of the MEA unit 12, corresponding to the membrane electrode assemblies 24(1)

through 24(n). As shown in FIG. 17, the first end 32a of the first electrically conductive layers 32 and the second end 34a of the second electrically conductive layer 34 are overlapped with each other such that the solid polymer electrolyte membrane 22 is interposed between the first and second ends 32a, 34a. The rivet member 36 is inserted in the overlapping area.

[0038]

The seal member 38 such as a silicon rubber is provided around the outer surface of the rivet member 36 for sealing the hole in the overlapping area to prevent leakage of the fuel gas and the oxygen-containing gas. The rivet member 36 is squeezed to form the flanges 36a, 36b which are tightly in contact with the first and second ends 32a, 34a. Thus, the cathode 28 of the membrane electrode assembly 24(1) and the anode 30 of the membrane electrode assembly 24(2) are electrically connected.

[0039]

Likewise, all of the membrane electrode assemblies 24(1) through 24(n) are electrically connected in series (see arrows in FIG. 4).

[0040]

In the third embodiment, the first end 32a of the first electrically conductive layer 32 of the first membrane electrode assembly 24(1) and the second end 34a of the second electrically conductive layer 34 of the second membrane electrode assembly 24(2) extend toward each other.

The first end 32a and the second end 34a overlap such that the solid polymer electrolyte membrane 22 and the silicon films 26a, 26b are interposed between the first end 32a and the second end 34a. The rivet member 36 is inserted into the overlapping area to electrically connect the overlapping first end 32a and the 134a, i.e., the cathode 28 of the membrane electrode assembly 24(1) and the anode 30 of the membrane electrode assembly 24(2).

[0041]

Thus, unlike the conventional structure, no dedicated Z-like connection plates are required. In particular, even if a large number of membrane electrode assemblies 24(1) through 24(n) are provided, the fuel cell 10 is produced at a low cost, and the reliable sealing performance can be achieved. The overall size of the fuel cell 10 is small, and the overall structure of the fuel cell 10 is simple.

[0042]

After the MEA unit 12 is interposed between the first and second separators 14, 16, through holes extending through the MEA unit 12, and the first and second separators 14, 16 are formed. The through holes are shown as the threaded holes 48 of the first separator 14, the holes 27 of the MEA unit 12, and the holes 62 of the second separator 16. Since the MEA unit 12 keeps the planar shape when the MEA unit 12 is interposed between the first and second separators 14, 16, the perforating operation for making the through holes at predetermined positions can be carried out

accurately.

[0043]

For example, the through holes (the holes 62 and the threaded holes 48) are sealed using a silicon rubber or the like for improving the sealing performance.

[0044]

Tightening screws 64 are inserted into the holes 62, and tip ends of the tightening screws 64 are screwed into the threaded holes 48, respectively. In this manner, the first separator 14, the MEA unit 12, and the second separator 16 are tightened together to form the fuel cell 10.

[0045]

Next, operation of the fuel cell 10 will be described.

[0046]

Firstly, referring to FIG. 1, an oxygen-containing gas is supplied to the oxygen-containing gas supply passage 20a and a fuel gas such as a hydrogen containing gas is supplied to the fuel gas supply passage 18a. Further, a coolant such as pure water, an ethylene glycol or an oil is supplied to the coolant flow fields 72.

[0047]

Specifically, as shown in FIG. 6, the oxygen-containing gas flows into the supply manifold 54 on the surface 16a of the second separator 16. Then, the oxygen-containing gas is supplied into the oxygen-containing gas flow field 58. The oxygen-containing gas flows through the flow grooves of the

oxygen-containing gas flow field 58 in the direction indicated by the arrow C along the cathodes 28 of the membrane electrode assemblies 24(1) through 24(n) for inducing a chemical reaction at the cathodes 28. After the oxygen in the oxygen-containing gas is partially consumed, the oxygen-containing gas is discharged into the oxygen-containing gas discharge passage 20b through the discharge manifold 56.

[0048]

Likewise, as shown in FIG. 5, the fuel gas flows into the fuel gas manifold 40 on the surface 14a of the first separator 14. Then, the fuel gas is supplied into the fuel gas flow field 44 connected to the supply manifold 40. The fuel gas flows through the flow grooves of the fuel gas flow field 44 in the direction indicated by the arrow C along the anodes 30 of the membrane electrode assemblies 24(1) through 24(n) for inducing a chemical reaction at the anodes 30.

[0049]

Thus, in the membrane electrode assemblies 24(1) through 24(n), the oxygen-containing gas supplied to the cathodes 28, and the fuel gas supplied to the anodes 30 are consumed in the electrochemical reactions at catalyst layers of the cathodes 28 and the anodes 30 for generating electricity. All of the power generation units, i.e., the membrane electrode assemblies 24(1) through 24(n) are electrically connected in series between the terminals 52 and 66 for outputting a desired level of voltage.

[0050]

[EFFECT OF THE INVENTION]

According to the fuel cell of the present invention, only with the electrically conductive member connecting the first and second ends of the first and second electrically conductive gas diffusion layers protruding toward each other, unlike the conventional structure, no dedicated Z-like connection plates are required. The reliable sealing performance can be achieved with the simple and economical structure. The overall size of the fuel cell is small, and the overall structure of the fuel cell is simple.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1]

FIG. 1 is an exploded perspective view showing main components of a fuel cell according to a first embodiment of the present invention.

[FIG. 2]

FIG. 2 is a cross sectional view showing main components of the fuel cell.

[FIG. 3]

FIG. 3 is a view showing connection state in an MEA unit of the fuel cell.

[FIG. 4]

FIG. 4 is a front view showing the MEA unit.

[FIG. 5]

FIG. 5 is a front view showing a first separator of the fuel cell.

[FIG. 6]

FIG. 6 is a front view showing a second separator of the fuel cell.

[FIG. 7]

FIG. 7 is a cross sectional view showing main components of a flat fuel cell disclosed in Patent Document 1.

[DESCRIPTION OF REFERENCE NUMERALS]

10: fuel cell, 12: MEA unit, 14, 16: separator,
18a: fuel gas supply passage,
18b: fuel gas discharge passage,
20a: oxygen-containing gas supply passage,
20b: oxygen-containing gas discharge passage
22: solid polymer electrolyte membrane,
24(1) to 24(n), 102(1), 102(2): membrane electrode assemblies,
26a, 26b: silicon film, 28: cathode, 30: anode,
32, 34: electrically conductive diffusion layer,
32a, 34a: end, 36: rivet member, 40, 54: supply manifold,
44: fuel gas flow field, 50, 59: seal, 52, 66: terminal,
58: oxygen-containing gas flow field

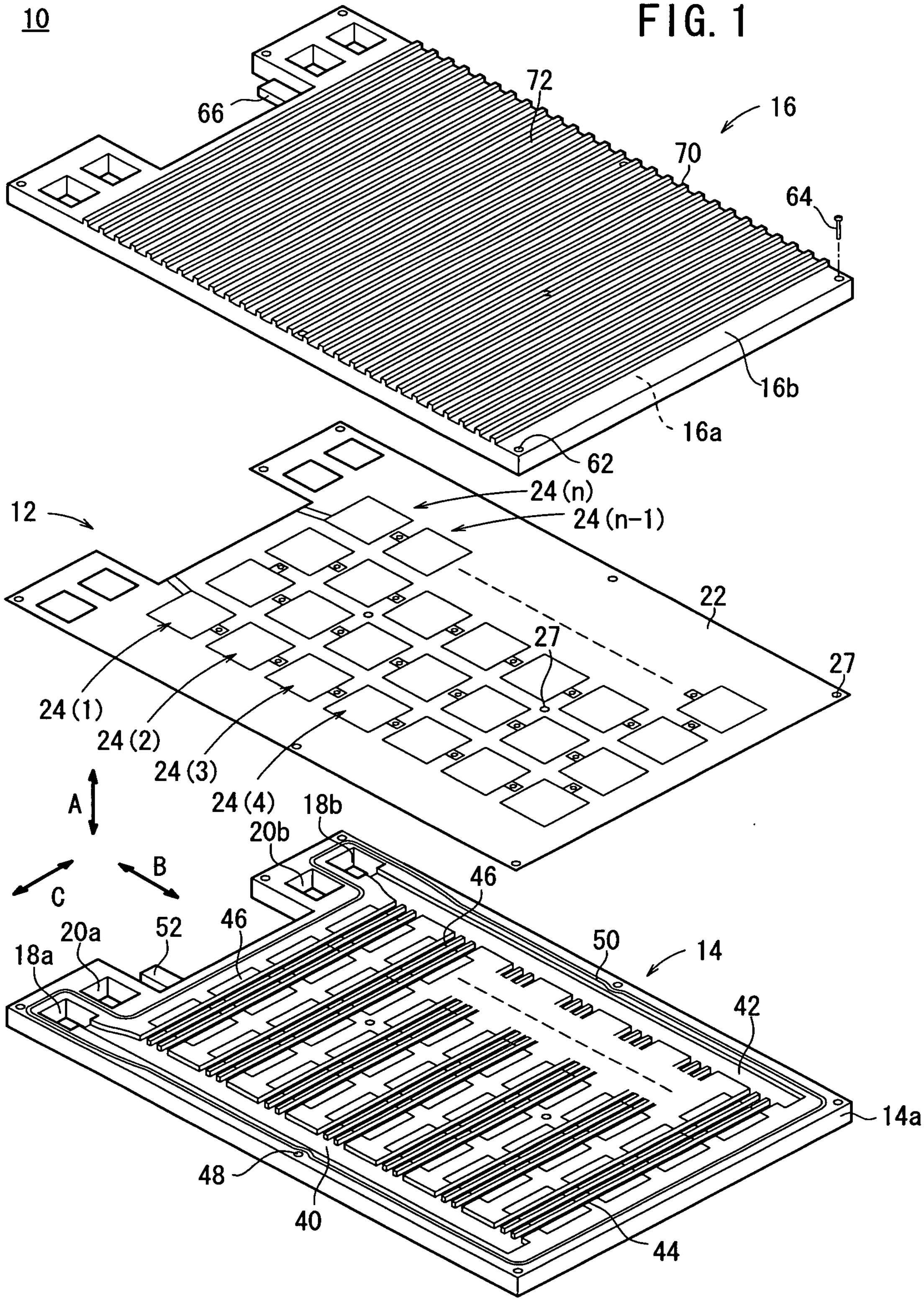

10
66
72
16
70
64
16b
16a
62
12
24 (n)
24 (n−1)
22
27
27
24 (1)
24 (2)
24 (3)
24 (4)
A
B
C
18b
20b
46
46
20a
52
18a
50
14
42
14a
48
40
44
FIG. 1

FIG. 2

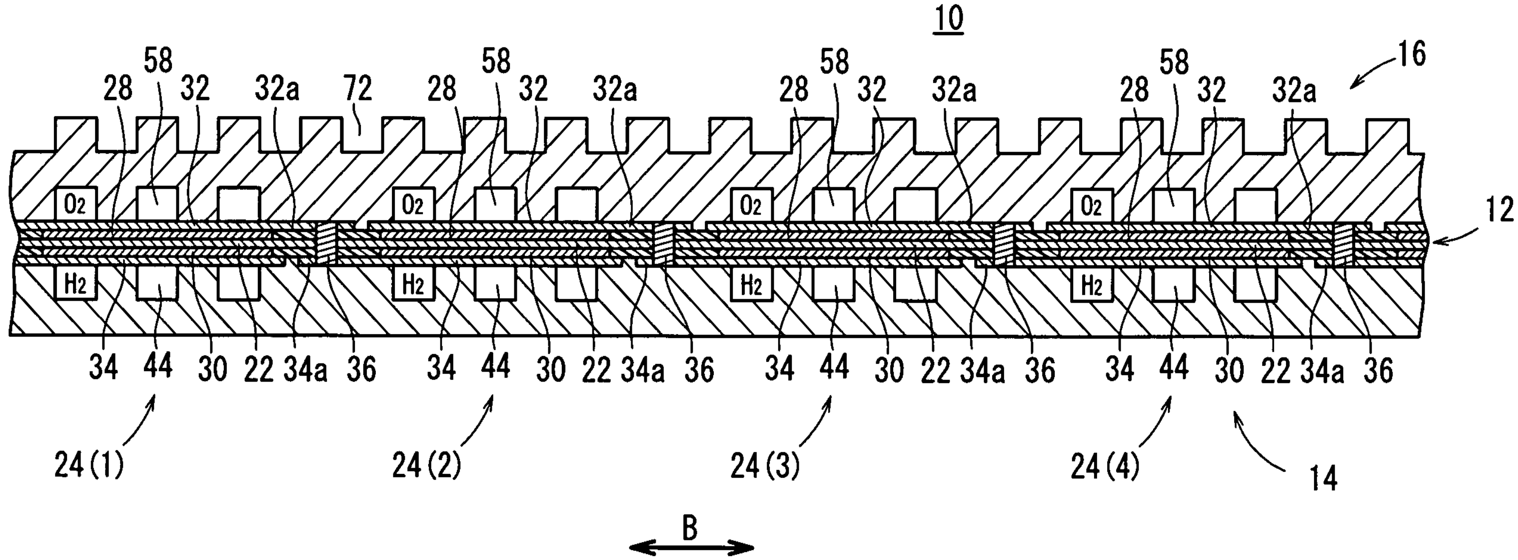
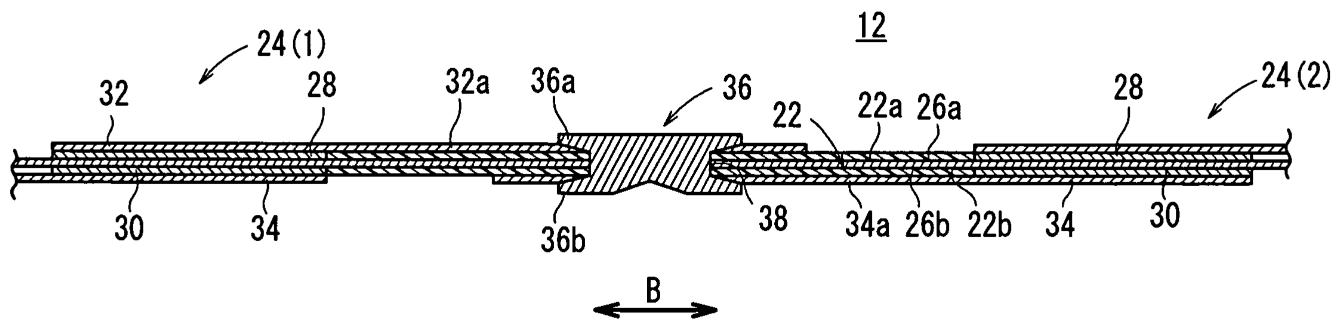


FIG. 3



12
24 (1)
32
28
32a
36a
36
22
22a
26a
28
24 (2)
30
34
36b
38
34a
26b
22b
34
30
B

FIG. 4

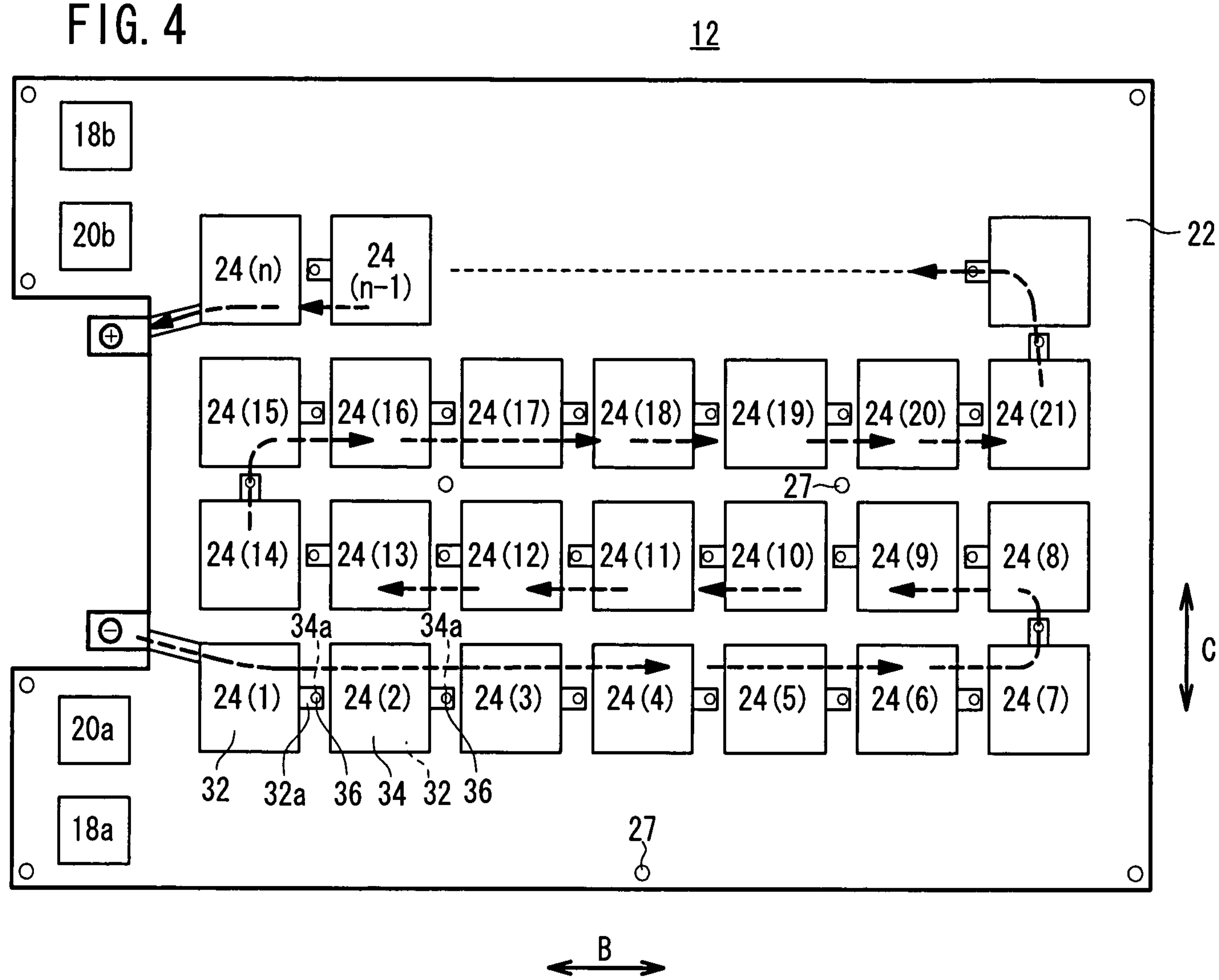

12
18b
20b
22
24 (n)
24 (n-1)
24 (15)
24 (16)
24 (17)
24 (18)
24 (19)
24 (20)
24 (21)
27
24 (14)
24 (13)
24 (12)
24 (11)
24 (10)
24 (9)
24 (8)
C
34a
34a
20a
24 (1)
24 (2)
24 (3)
24 (4)
24 (5)
24 (6)
24 (7)
32
32a
36
34
32
36
18a
27
B

FIG. 5

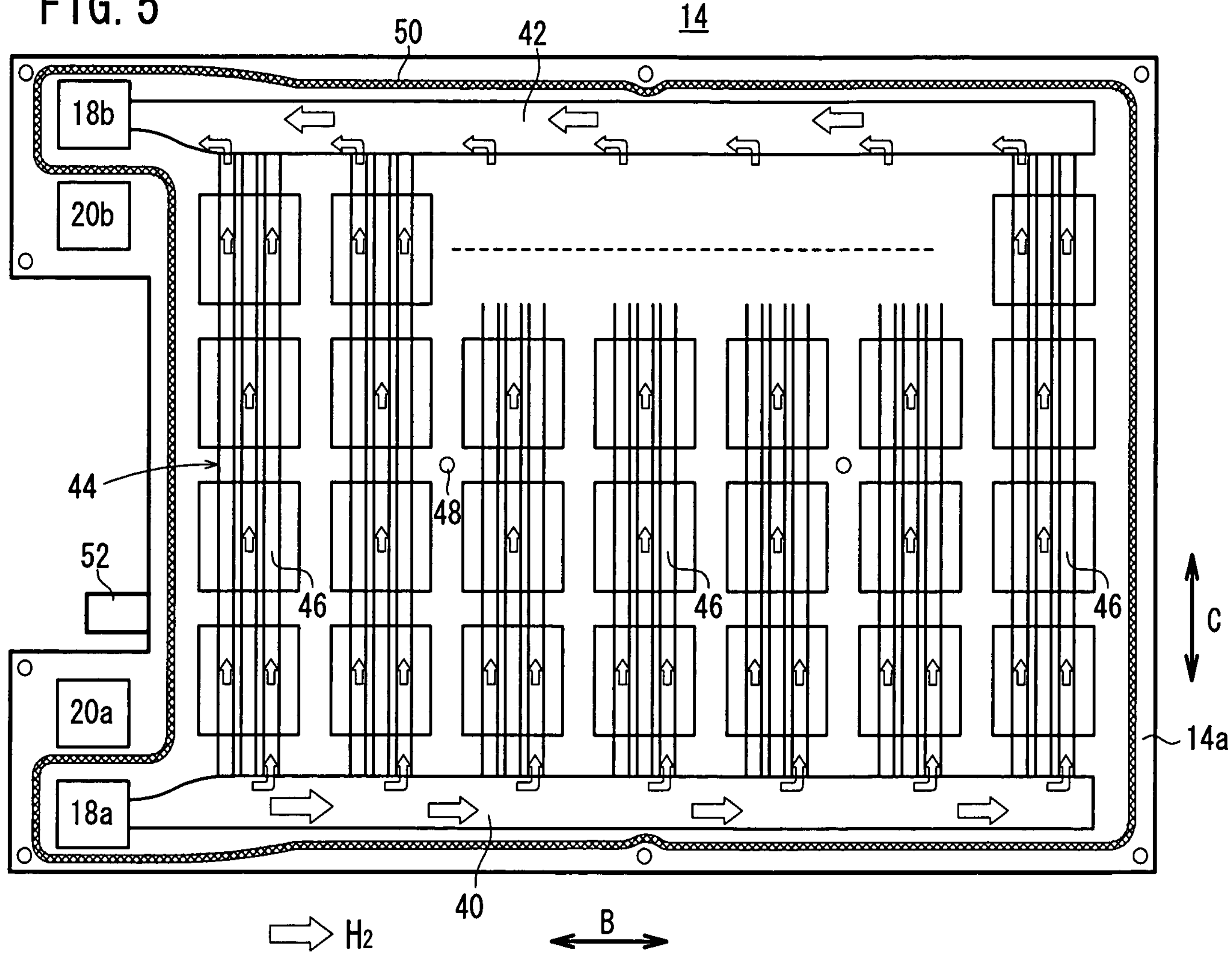


FIG. 6

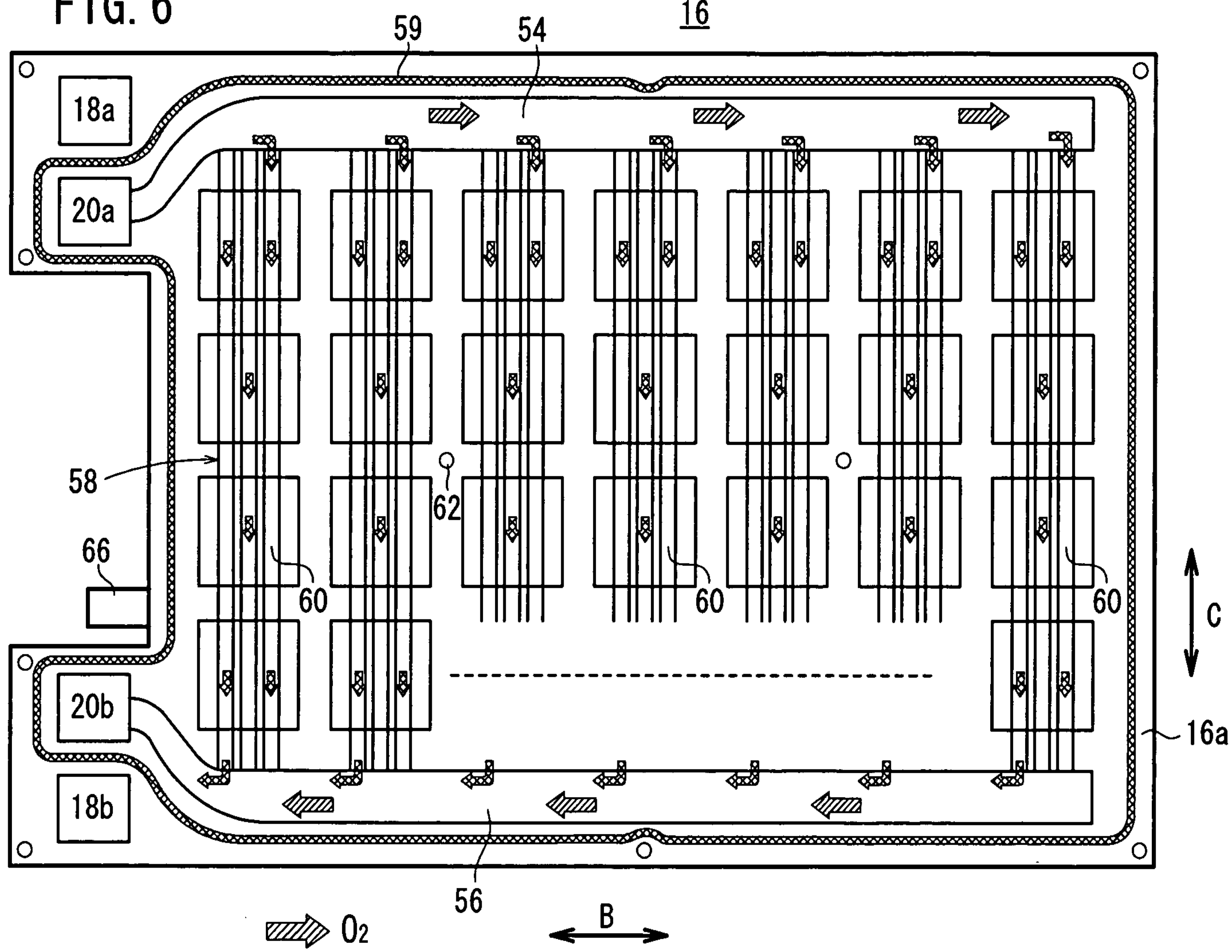
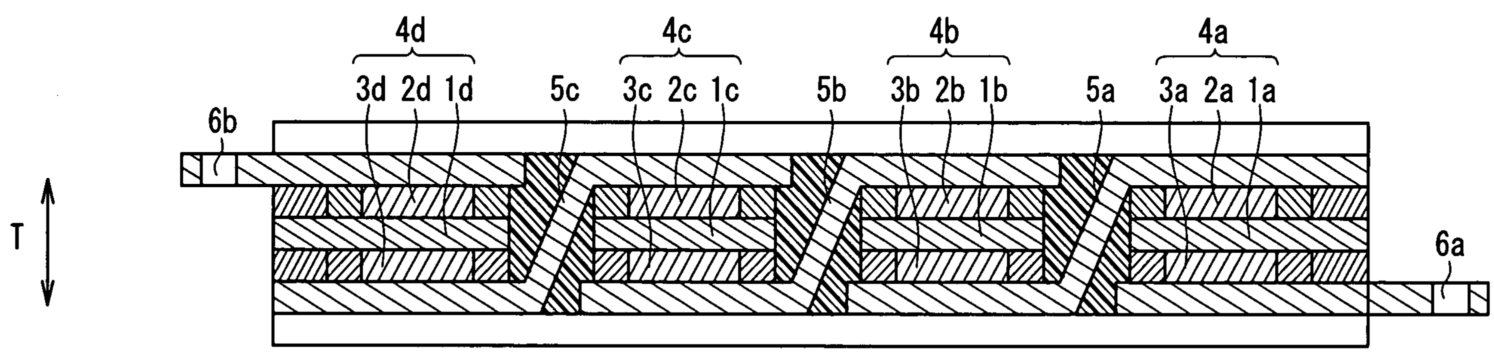


FIG. 7



[DOCUMENT NAME] Abstract

[ABSTRACT]

[TASK] To ensure a desired voltage with a simple and compact structure while electrically connecting a plurality of power generation units in series.

[SOLUTION] A first electrically conductive gas diffusion layer 32 of a membrane electrode assembly 24(1) has a first end 32a, and a second electrically conductive gas diffusion layer 34 of a second end 34a. The first and second ends 32a, 34a overlap such that a solid polymer electrolyte membrane 22 is interposed between overlapping portions of the first and second ends 32a, 34a. The overlapping portions are electrically connected with each other by an electrically conductive rivet member 36. The overlapping portions are electrically connected with each other by an electrically conductive rivet member 36.

[SELECTED FIGURE] FIG. 3